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FRENCH DEVELOPMENT OF NUCLEAR WEAPONS DELIVERY SYSTEMS

PROBLEM

To assess the probable nature, effectiveness, and timing of the various French nuclear weapons delivery systems.

CONCLUSIONS

1. The French will have developed three nuclear weapons delivery systems by 1970. The Mirage IV aircraft/nuclear bomb system is already partly operational. A land-based IRBM system in hardened sites probably is being developed; if so, deployment probably will begin in late 1967. A nuclear submarine/ballistic missile system is also under high priority development, but the first submarine will not begin sea trials until 1969 or early 1970.

2. The French deterrent force will be slight until an effective IRBM has been developed and a limited number of them deployed. By 1975, this force probably will have grown into a mixture of land-based IRBM's and ballistic missile submarines, which, though limited in numbers, will comprise an effective nuclear strike force against population centers.

3. The Mirage IV delivery system has several weaknesses, chief among which are its inadequate range for strikes against the USSR and its probable inability to achieve a mass penetration of Soviet Bloc defenses. The French are trying to increase the range of the bomber and also plan to use refueling, but cannot strengthen the system sufficiently to make it effective for mass penetration.

4. The probable land-based IRBM delivery system would employ a solid-propellant two-stage missile. The Grenoble region of metropolitan France may have been chosen as the area of silo deployment. The number of missiles to be land-based cannot be estimated reliably; indications vary from 50 to 200.

5. The French nuclear ballistic missile submarines will be slightly larger than the newest US missile submarines. The announced design range of its missiles is 2,000 to 3,000 kilometers (1,080 to 1,620 nautical miles). The range of 1,620 nautical miles is adequate to reach practically all Soviet population centers west of the Urals. From three to five of these submarines are planned. By the time the first one is operational in the

early 1970's, we believe that an adequate solid-propellant missile will have been developed for this system.

DISCUSSION

THE MIRAGE IV NUCLEAR WEAPONS DELIVERY SYSTEM

A force of 50 Mirage IV supersonic bombers is the planned "first generation" nuclear weapons delivery system of the French force de dissuasion.[1] Twelve reportedly have been delivered through mid-1964. The scheduled production rate is 2 per month with the fiftieth unit to be delivered in 1966. According to the air section of a French Senate report of 13 November 1963, an additional 12 are planned for production during 1966; perhaps to take care of anticipated attrition and to provide a small number of specialized aircraft. The principal characteristics of the bomber (see figure 1) are as follows:

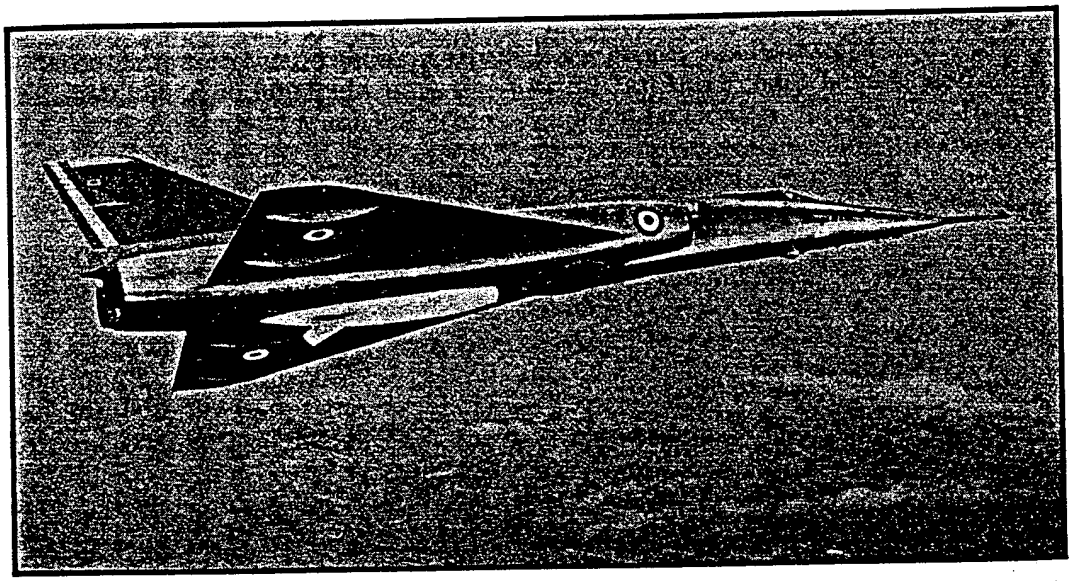
Maximum takeoff weight	65,000 lbs.
Internal fuel	28,585 lbs.
Bomb load	3,400 lbs.
Engine thrust (with afterburner)	14,940 lbs. (each of 2 engines)
Maximum speed at sea level	Subsonic
Maximum speed at altitude	2.0 Mach
Maximum radius at low altitude	565 n.m.
Basic radius of operation	1,000 - 1,100 n.m.*

*The French have stated, without explanation, that the range is 1,350 nautical miles without refueling, but this figure probably represents optimum performance.

The Mirage IV delivery system has been termed obsolete and inadequate by many, including some importantly placed French officials. Only the major Soviet cities of Minsk and Kiev are within its 1,000-mile range

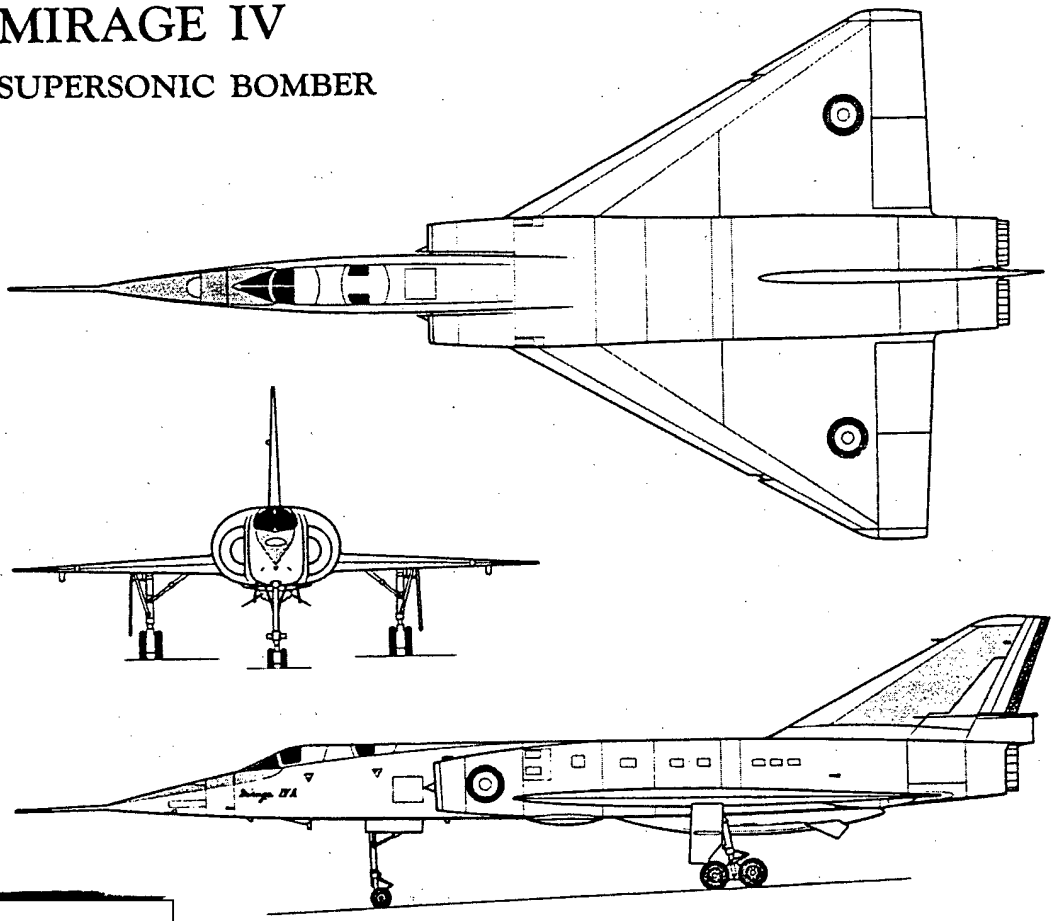
Yet it is possible that a few of the of 50 Mirage IV's could penetrate Soviet air defenses on a nuclear strike. Such a strike would presumably involve a maximum effort to use all available bombers and would be preceded by a maintenance standdown, which, with other indicators, would probably betray French intentions to the Soviet Union. Nothing the French could do would materially increase the Mirage IV's ability to penetrate Soviet defenses. Thus, as a nuclear threat against the Soviet Union, the Mirage IV is gravely deficient.

Figure 1



MIRAGE IV

SUPERSONIC BOMBER



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To reach targets within the Soviet Union, an actual mission would necessarily be flown at 40,000 to 50,000 feet where the Mirage IV cruises at about Mach 0.9. This speed and altitude render it extremely vulnerable to attack by the extensive Soviet surface-to-air missile defenses and the approximately 2,000 Soviet fighters deployed west of Moscow. Better penetration of Soviet air defenses would be achieved by attack at altitudes below 5,000 feet and at subsonic speeds, but the range of the bomber under these conditions is only 530 nautical miles. Thus Soviet targets could not be reached with low-level missions from France. There has been considerable reporting on various French schemes to increase the strike capability of the Mirage IV. Twelve Boeing KC-135 jet tankers have been purchased for aerial refueling of the bombers but even successful refuelings will not greatly improve the range capability of the system.* Figure 2 illustrates the range capability of the bomber both under the condition of refueling and for a direct flight over NATO territory. It also graphically depicts the air defenses of the Soviet Union and its allies.

There are three possible routes that a bombing mission to the USSR might take: a northern dog-leg route over the Baltic; a southern dog-leg route over the Mediteranean; and a direct route due east over Germany and through the heaviest concentration of Soviet air defenses. The 1,150-nautical-mile combat radius of the Mirage IV would not permit the aircraft to reach Moscow itself using any of these routes, although numerous centers of population west of Moscow could be brought under attack. If the French were to acquire air-to-surface missiles (ASM) and attack due east, the Mirage IV's missiles might possibly reach the Moscow area. But the French have stated only that "consideration" is being given to air-to-surface missiles, hence, this eventuality cannot be assumed. In any event, the 3,500-pound payload of the Mirage IV would limit the size and range of any ASM, making it necessary for the aircraft to travel a considerable distance through Soviet Bloc air defenses before the ASM could reach target areas.

There appears to be considerable dissatisfaction with the Mirage IV even on the part of Marcel Dassault, the designer. The aircraft was first designed in 1957 as a strategic bomber of more than 100,000 pounds gross weight, which would have had much greater range than does the present bomber of 66,000 pounds gross weight.[2-4] For unknown reasons Dassault was forced to reduce the size to the smaller figure thus lowering the range to its present marginal figure.[2 4] There is strong evidence that in 1963 the Government seriously considered redesigning the aircraft upward to a gross weight of 90,000 pounds in order to acquire greater range.[5 6] This scheme now appears to have been rejected in favor of refitting the later units of the production run with more powerful engines. But even this proposal is meeting with serious difficulties.

The original engine of the Mirage IV is the Société Nationale d'Étude et de Construction de Moteurs d'Aviation (SNECMA) ATAR-9K turbojet having a thrust with afterburner of about 14,940 pounds. It has been reported that this engine will be replaced by a more powerful US Pratt and Whitney engine which is being built in France by SNECMA under license.[7-11] The French designation of this engine is TF-106. SNECMA

*Four or five tankers had been delivered by mid-1964.

has encountered serious difficulties in building these engines and appears to have cancelled this effort and decided to build under license the Pratt and Whitney TF-30 in its stead.*[8 9 12 13] Dassault has purchased two Pratt and Whitney TF-30 engines for the first Mirage III-V aircraft at a cost of $1,000,000 each, and other purchases will follow until SNECMA is able to build satisfactory engines.[12 14] Thus, despite the desire of the French to fit the Mirage IV bombers with larger engines, the production run of these bombers will probably be over half finished by the time these engines become available in quantity. Therefore, the French appear forced either to accept the shorter range given by the present ATAR-9K engine or to later refit the aircraft with more advanced engines. The range of the Mirage IV with TF-30 engines would be about 1,400 nautical miles.

In summary, the French appear to have embraced a first generation nuclear weapons delivery system of dubious and marginal effectiveness. The "deterrent quality" of this force appears to lie only in the fact that the Soviets could never be sure that some Mirage IV's would not penetrate their defenses. At this point the French can only scrap the bomber program or accept its limitations, which will surely become more acute as the aerial defenses of the Soviets increase in effectiveness in the next few years. It was perhaps the realization of these unpalatable facts which prompted them to consider employing IRBM's in numbers on French soil.

*The French plan to use the TF-106 engine to power the new Mirage III-V aircraft, some 300 of which may ultimately be produced by Générale Aéronautique Marcel Dassault (GAMD).

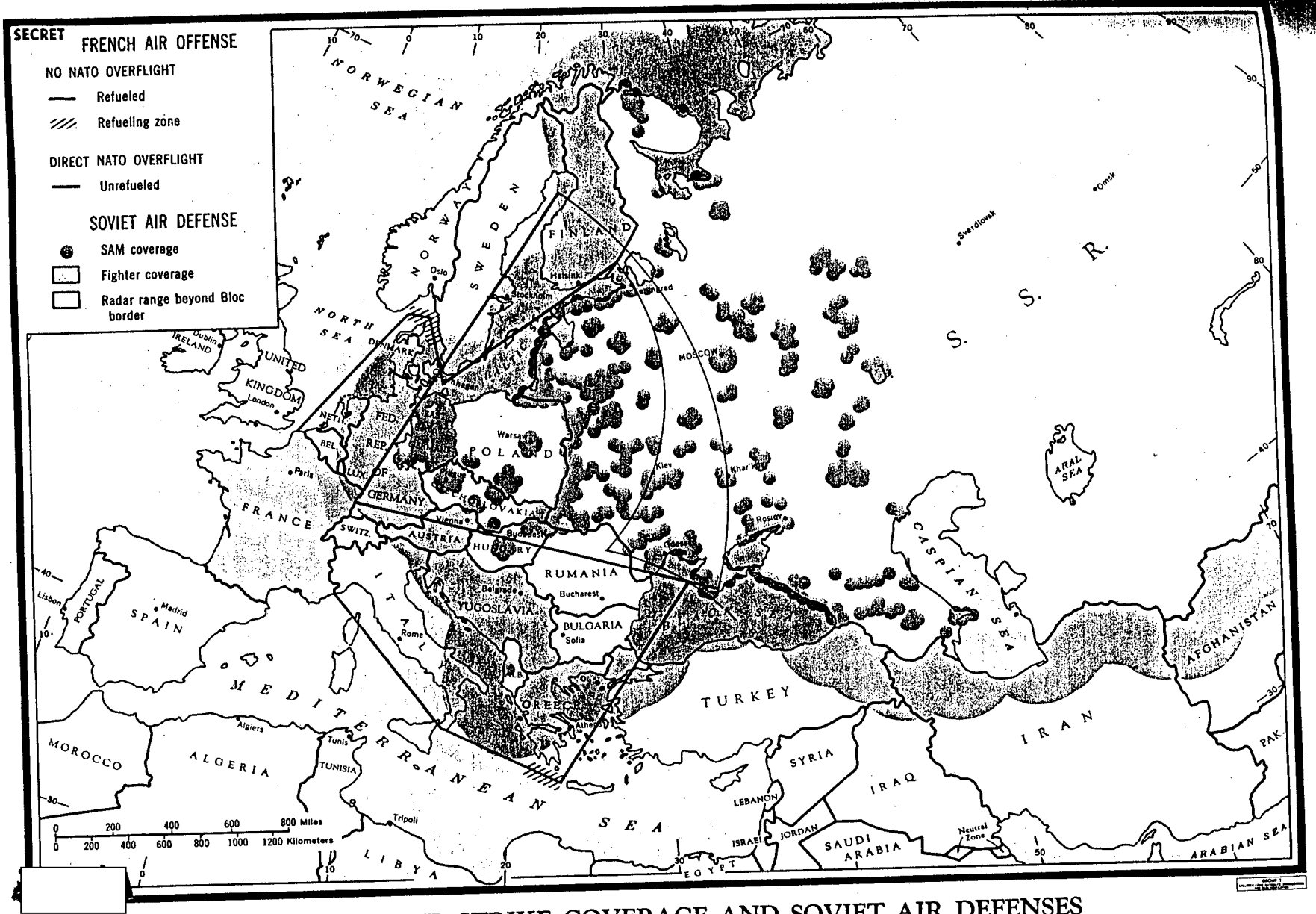
NUCLEAR SUBMARINE BALLISTIC MISSILE DELIVERY SYSTEM

The French contracted with the United States in 1959 for the delivery of sufficient enriched U-235 to permit the construction of a land-based submarine propulsion reactor. In 1960 they apparently decided to make their first nuclear submarine a ballistic missile type. They very sensibly decided to finish the hull of their earlier attempted nuclear submarine design (on which construction was abandoned in 1958) as a conventionally propelled submarine test platform with four missile tubes installed. This vessel, the Gymnote,* was launched in March 1964.[15]

[redacted] the dimensions of the Gymnote's missile tubes as 72 inches in diameter and 34.8 feet in length.[16] These dimensions, if correct, indicate that the French have fixed the design length of the missile to be carried at about 32 feet. With a 72-inch tube diameter, a missile diameter of about 54 to 58 inches would be appropriate. Based upon these dimensions, a missile gross weight of about 35,000 pounds is indicated. These design parameters of length and gross weight will demand that the French have a reentry vehicle weighing no more than 1,500 pounds, assuming they are able to achieve an overall missile performance comparable to that of the US Polaris A2.

The French publication Air et Cosmos states that the first nuclear submarine was "placed on stocks" in 1963 at Cherbourg Naval Shipyard. Figure 3 shows the

*Gymnote translates "electric eel."



MIRAGE IV AIR STRIKE COVERAGE AND SOVIET AIR DEFENSES

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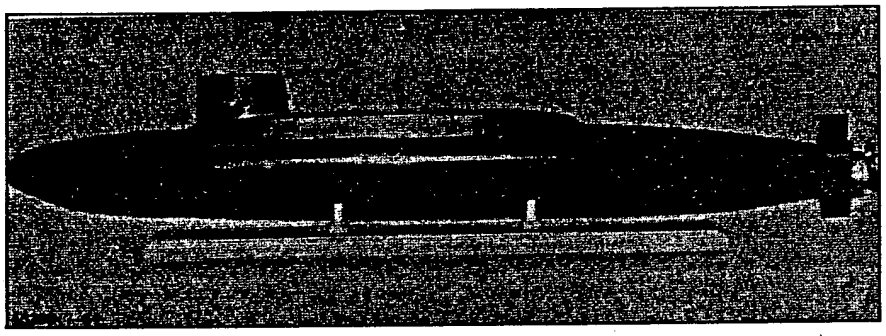
Figure 2

Figure 3



MODEL OF FRENCH BALLISTIC MISSILE NUCLEAR SUBMARINE

submarine's profile according to the French press. Its announced characteristics are as follows:[15]

Displacement*	7,900 tons (surface)
Displacement	9,000 tons (submerged)
Length	420 feet
Speed	20 knots
Number of torpedo tubes	4
Number of missiles	16
Number of propellers	1
Operating depth	More than 200 meters
Number of propulsion turbines	2
Number of turbo-alternators	2
Number of crew	135

*The surface displacement of the newest US missile submarine is 7,000 tons.

The announced design range to the submarine's 16 missiles is 2,000 to 3,000 kilometers or 1,080 to 1,620 nautical miles.[17] Figure 4 illustrates the city targets which could be reached from firing positions in the Mediterranean and Norwegian seas. Practically every Soviet center of population east of the Urals is within the longer range. The figure also graphically displays the number of missiles which the French can place on station with one, two, and three submarines. A minimum of three submarines is necessary to achieve a consistent number of missiles on station. In fact, some responsible French sources have stated that a total of five missile-firing submarines will ultimately be completed.[18] [19]

The prototype nuclear propulsion plant for these submarines, which has been under construction since 1961 at Cadarache, will probably become operational in late 1964. It will serve as a training device for future submarine personnel. Practically all of the plant, including the reactor pressure vessel, but excepting the reactor core and controls, is being made by the Naval Boiler and Turbine Plant at Indret. At this installation in May 1963, the six-foot-diameter cover for the Cadarache reactor pressure vessel was viewed by US Navy personnel.[20]

Official French statements speak of having the first nuclear submarine, the Coelacanthe, "in service" in 1969, but 1970 is a more realistic date for sea trials of the submarine itself.[21] The missiles with which the submarine will be fitted are discussed in appendix A of this paper. Figure 5 shows the French Navy and CEA organization concerned with the design and construction of the submarine.

LAND-BASED IRBM SYSTEM

There are very strong indications but no certainty that the French will deploy IRBM's in metropolitan France. In April 1963 Defense Minister Messmer, writing in Revue de Défense Nationale, strongly inferred that ballistic missiles would not be deployed in metropolitan France. He said:

> After a missile and nuclear charge are available, the choice of launching platform remains. Should it be a ground, naval, air, or space platform? The decision depends not only on technical factors but on strategic and political ones as well. Technically speaking a land-based site, mobile or stationary – possibly buried underground – is the most simple and the most economical; militarily and politically speaking, such sites raise problems for a relatively small country like France. That is why the nuclear-powered submarine has been selected as the most advantageous launching platform.

Messmer on 7 November 1963 also stated in part, according to Le Monde: "Discussions on the advisability of equipping France with atomic weapons may now be filed away, since the atomic force of the first generation (the Mirage IV delivery system) has become a fact. Therefore, it is possible to push the development of the next generations, which will consist essentially of missiles and submarines."

Although this later statement shows consideration of missiles, it implies that the decision to go ahead with land-based systems had not been finally taken. But the decision had apparently been made,

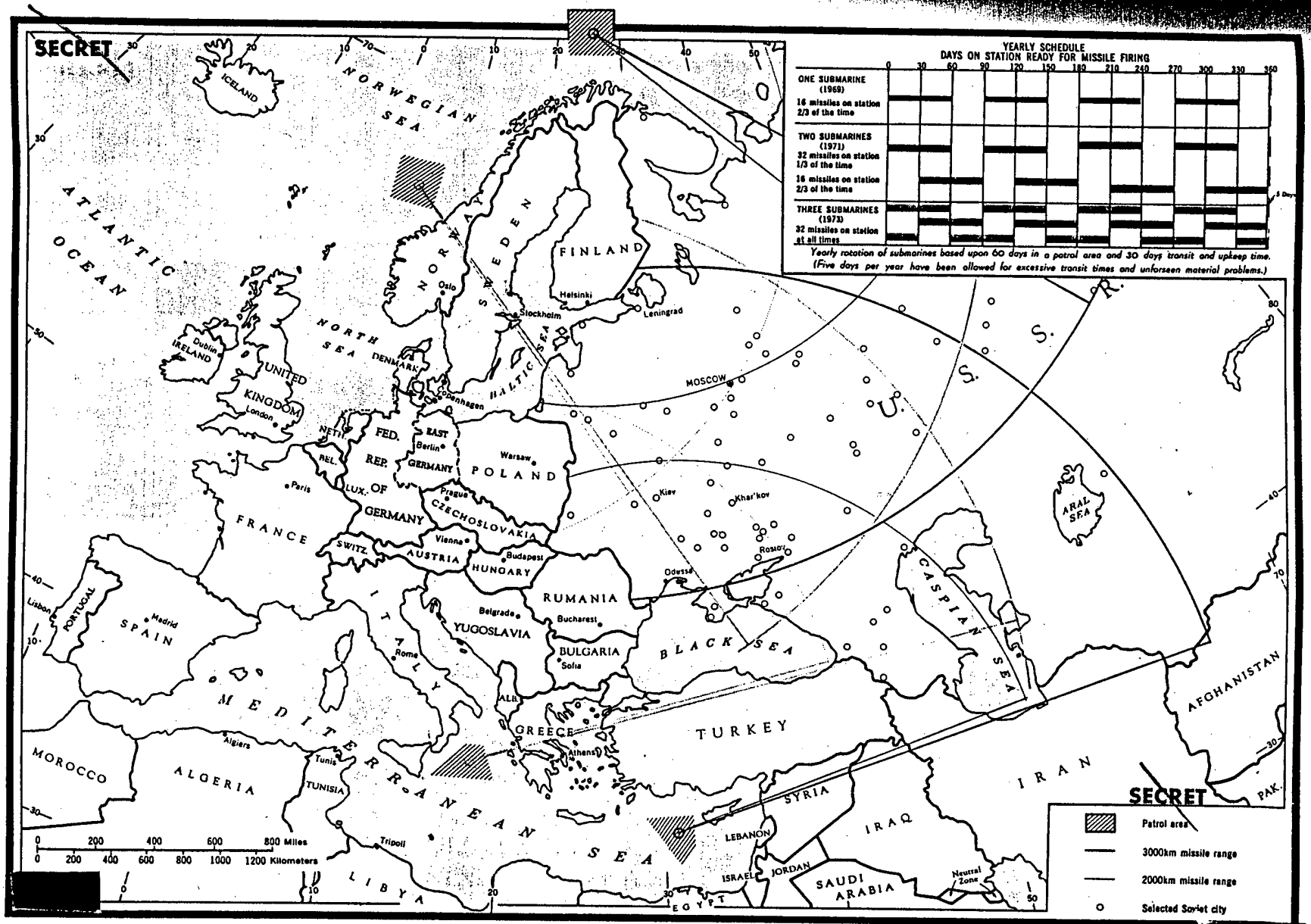


Figure 4

SUBMARINE-LAUNCHED BALLISTIC MISSILE COVERAGE OF THE USSR

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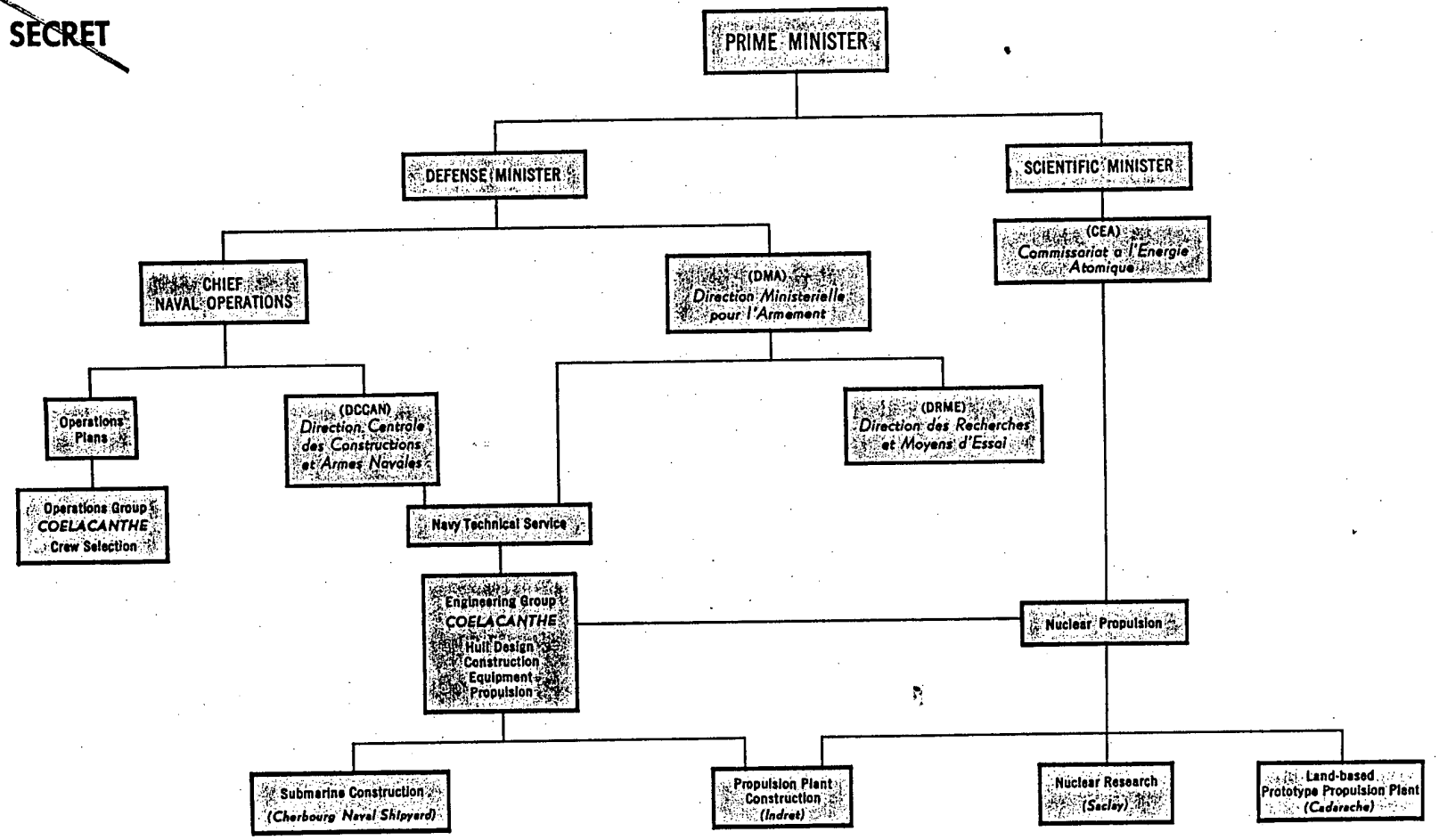

FRENCH ORGANIZATIONS CONCERNED WITH NUCLEAR SUBMARINE DESIGN AND CONSTRUCTION

Figure 5

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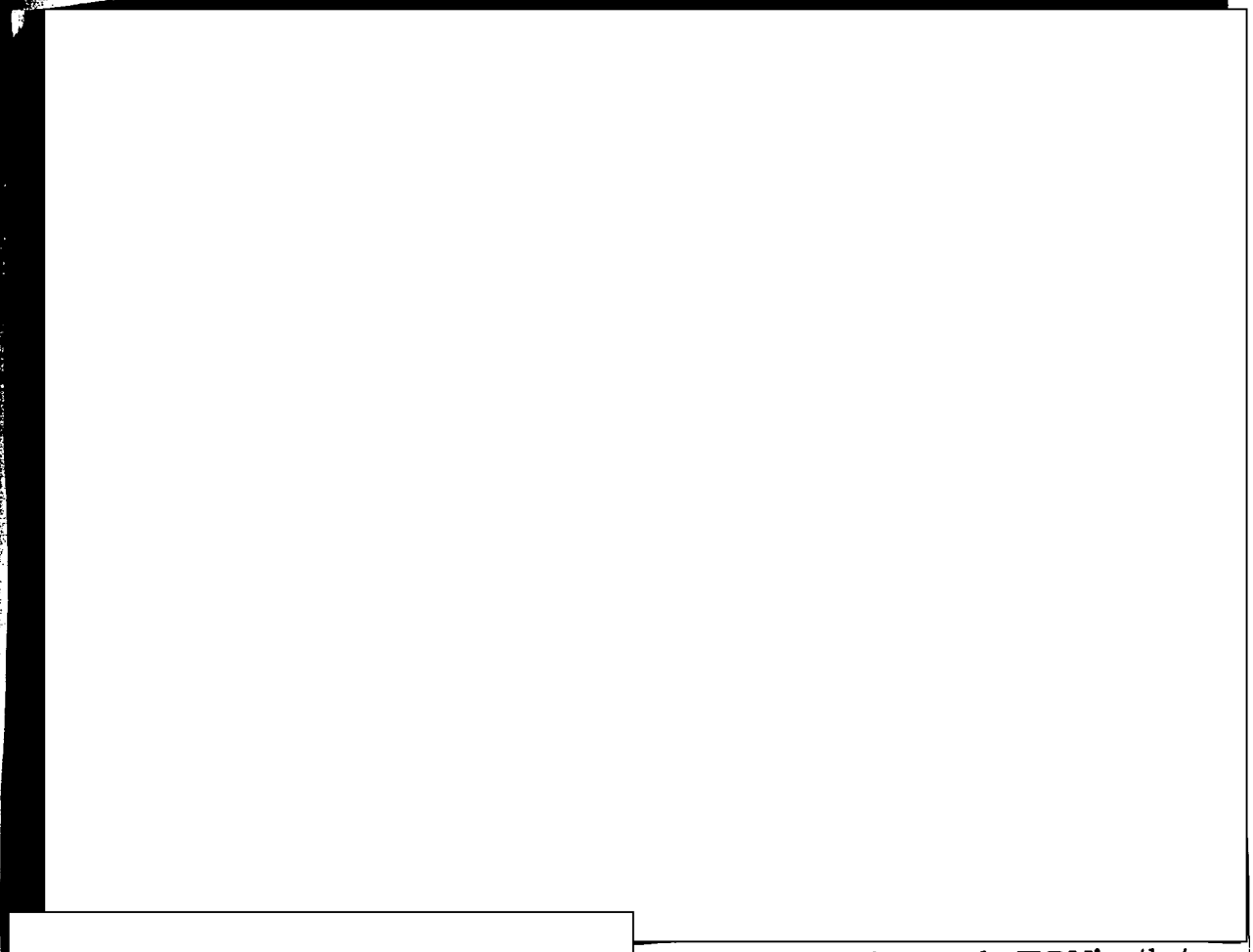
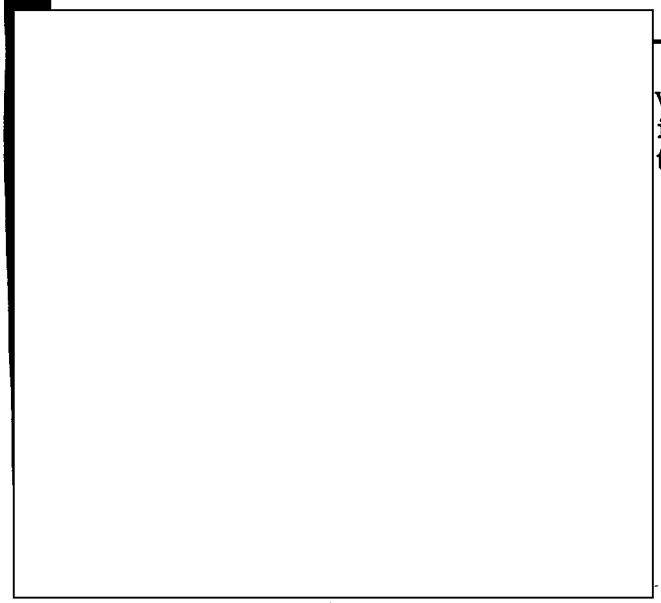




The number of French IRBM's that would be land-based varies widely in intelligence reports. Chevalier reportedly said in January 1964:[23]

> The first operational missiles will be put in silos, similar to the Minuteman. Later, in 1969 or 1970, they will become operational on nuclear submarines. At this time it is planned that the total missile force will be divided about 40 percent land-based and 60 percent on

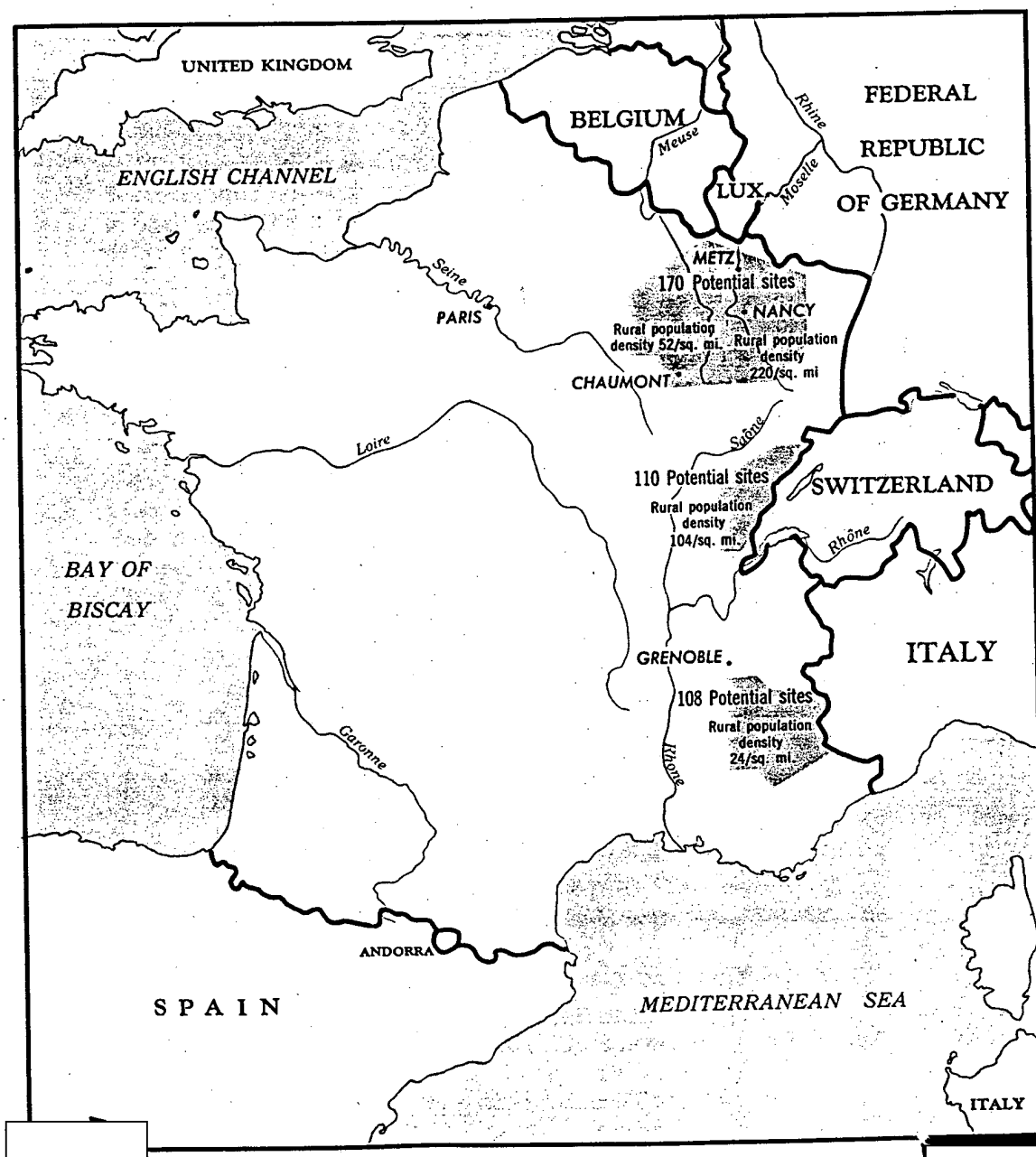
submarines. However, SEREB, for one, feels very strongly that land basing is far more desirable, and it is very possible that this ratio will be changed.

Based upon Chevalier's distribution and assuming a total of 5 submarines, 50 missiles would be land-based. [redacted] 60 to 70 land-based missiles are contemplated. On the other hand, in March 1964 the French consortium SERMIAT (Société d'Étude et de Réalisation de Matériels et d'Installations Aéroterrestres) unsuccessfully approached a US firm, which had designed and built Minuteman silos, for technical aid in eventually building 150 to 200 silos in metropolitan France.[24] The proposed agreement would have included initially a feasibility study to be followed by the construction of two prototype silos, presumably in the Bordeaux rangehead area.

[redacted] the French definitely now plan to acquire land-based IRBM's in the 1967-68 time period, but until test firing on the Bordeaux range begins, their ability to meet this schedule cannot be reliably judged. They could at any time within the next year or so reverse their seemingly affirmative decision with some sacrifice of money or effort, but if work continues, they could start to deploy strategic land-based missiles in hardened sites in late 1967. Present evidence strongly indicates that these missiles would be deployed under the French Air Force.

Figure 6

POTENTIAL AREAS OF IRBM SITES IN FRANCE



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APPENDIX A

BALLISTIC MISSILE RESEARCH AND DEVELOPMENT IN FRANCE

All French missile activity is carried out through the organization Societe pour les Etudes et Realisation des Engins Balistiques, abbreviated as SEREB, a consortium of various French governmental and private organizations. SEREB is the "systems manager" for all French missiles, as opposed to the US practice of having a systems manager for each missile system. SEREB does no manufacturing and has offices in Paris where it accomplishes feasibility studies, decides what is to be done, and delegates the actual work to members of the consortium or to outside contractors as it sees fit.

SEREB is responsible to the Direction Ministérielle pour l'Armément (DMA), which is composed in turn of the major divisions: Department des Engins (DE) for vehicles and the Direction des Recherches et Moyens d'Essai (DRME) for research and testing support. Within the DMA, SEREB falls under the DE, as shown by figure 7, through which it receives funding. It is headed by a board of directors with representatives from the following organizations:

Nord-Aviation
Sud-Aviation
SNECMA (Société Nationale d'Étude et de Construction de Moteurs d'Aviation)
Service des Poudres
ONERA (Office National d'Études et de Recherches Aéronautiques)
SEPR (Société d'Étude de la Propulsion par Réaction
GAMD (Générale Aéronautique Marcel Dassault)
MATRA (Societe Generale de Mecanique, Aviation et Traction)
CEA (Commisariat à l'Énergie Atomique)*

SEREB itself has four major divisions; Design, Tracking, Testing, and Ground Equipment. Realistically speaking, discussions of the activities of the member firms are discussions of the activities of SEREB itself, except where otherwise indicated.

*CEA is not a member of the consortium.

The main French firms engaged in missile and space activity are listed in appendix B. Some leading personalities in the weapons delivery systems program are listed in appendix C.

All French military missiles will use solid propellants. Solid propellant development and testing is exclusively the function of Service des Poudres, founded by Napoleon Bonaparte and probably today the most knowledgeable organization in this field in the free world outside the United States. Plants of Service des Poudres have been visited many time by US engineers, usually in connection with NATO Hawk missile production. As early as 1961, solid grains measuring one meter in diameter were being produced and it was noted that facilities were being installed for the manufacture of grains of very large size.[26] Also in 1961, a solid propellant engine about 12 feet long and 3 feet in diameter was observed at a plant of Nord-Aviation, and the observer was told it was part of the MRBM program.[27] Several other reports also indicate that the French, perhaps as early as 1959, decided to work toward a military missile of medium or intermediate range.

That the French are planning to produce large solid propellant grains is attested by their taking delivery in March 1964 of a large and modern glass filament case winding machine from the United States.[28] The machine was installed in a Sud-Aviation plant near the Bordeaux plant of Service des Poudres and has sufficient capacity to wind a missile grain case 8 feet in diameter and 27 to 28 feet in length.

they planned to wind the cases directly on the grains. This is an efficient method of forming solid rocket engines but is somewhat dangerous and final inspection of case and grain is more difficult. Possibly with winding directly on the grain in view, it was specified that the machine be able to carry a 40,000-pound mandrel weight, which reflects roughly a grain 4 feet in diameter and 27 feet long.

the initial production would be wound grains about 4 feet in diameter and 6 feet in length at the modest rate of 4 or 5 units a month beginning in April 1964. The end use of these grains is unknown because they do not appear to "fit" any presently known French rocket or missile.

The physical characteristics of the probable French land-based IRBM cannot to be stated with assurance. As opposed to the submarine missile — whose physical characteristics are rigidly defined by the range required, the weight and size limits of the reentry ve-

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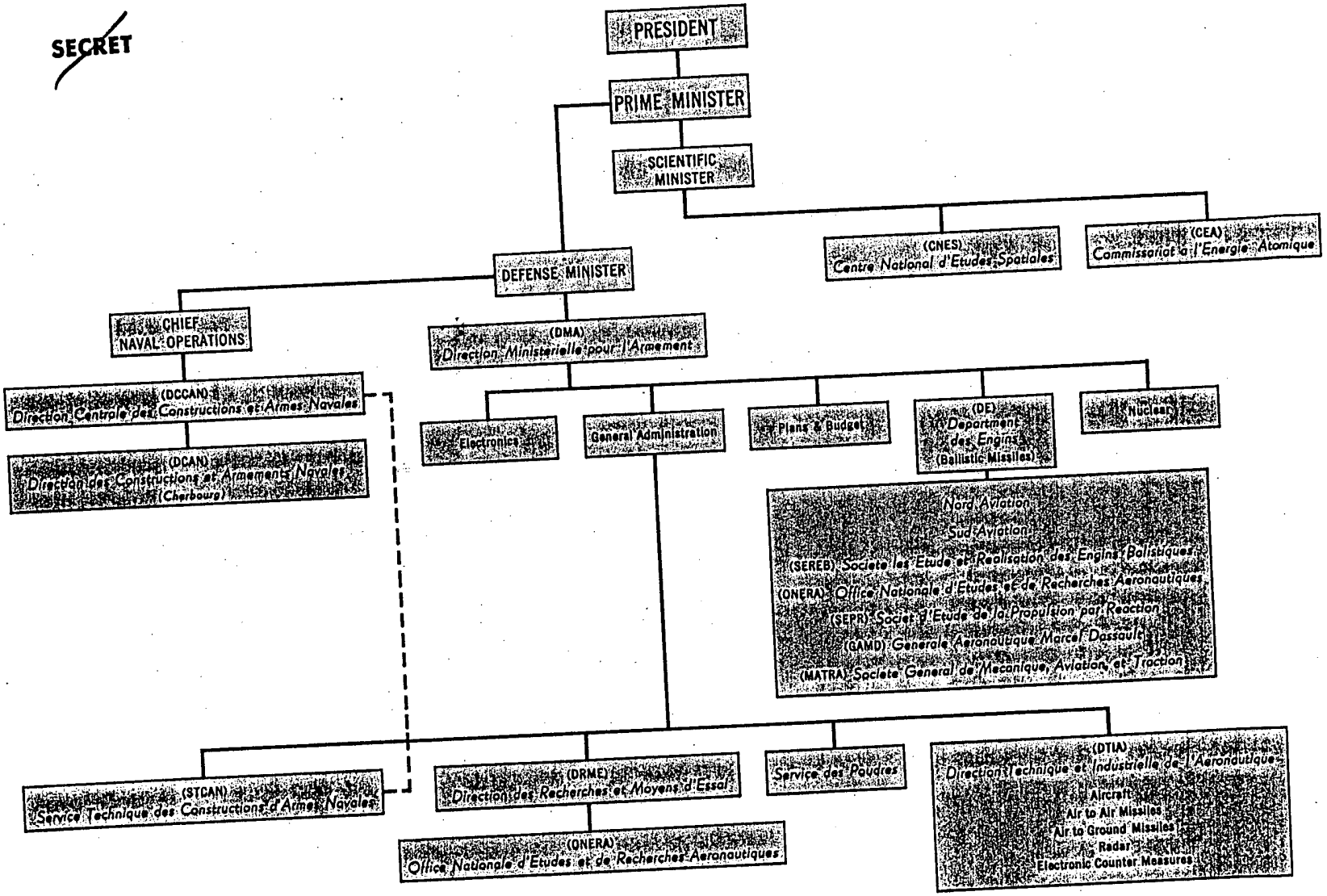

ORGANIZATION OF DIRECTION MINISTERIELLE POUR L'ARMEMENT (DMA)*

*Abbreviated org

Figure 7

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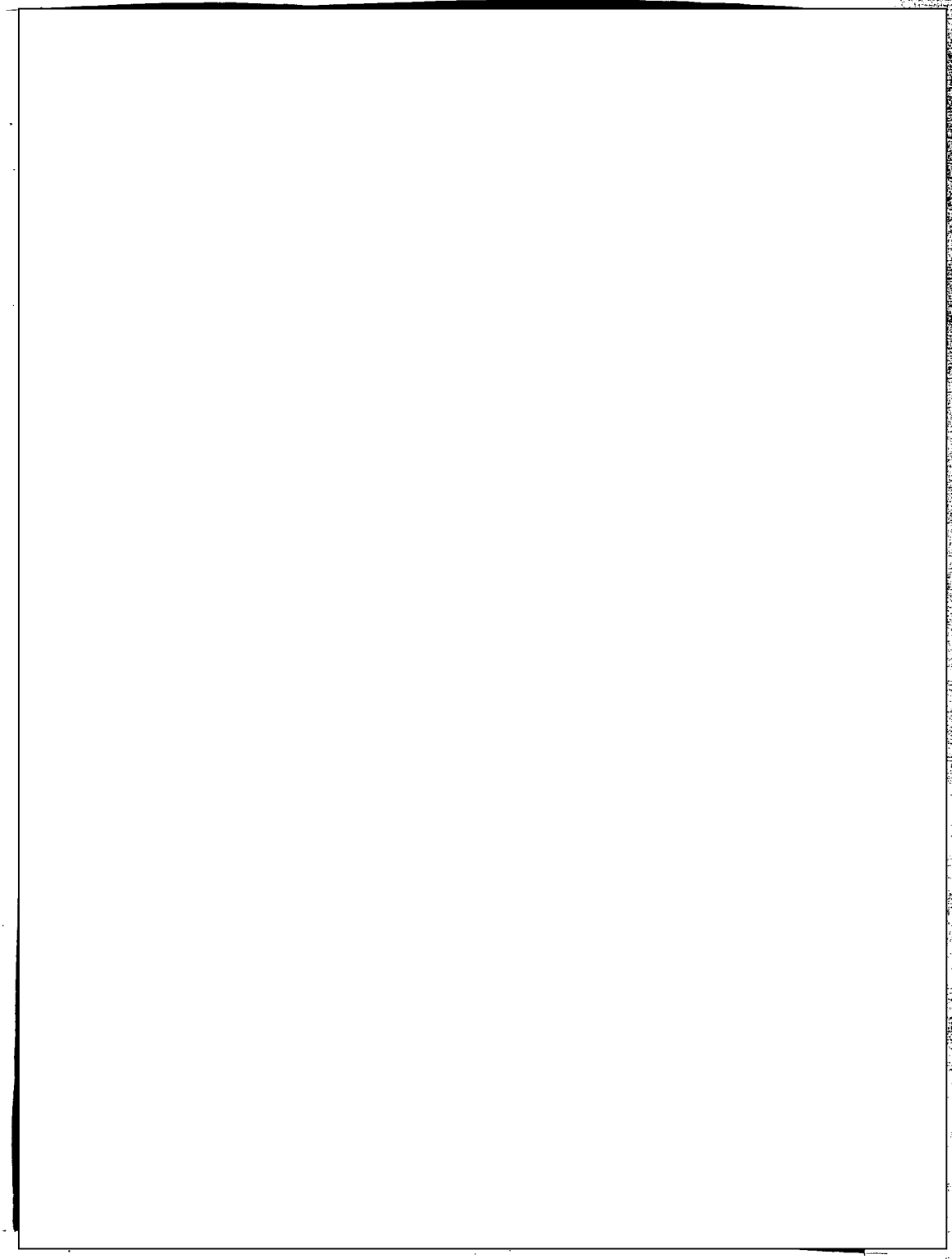
hicle, and the size of the submarine's tubes — the size of the land-based IRBM may vary over a fairly wide range depending upon the chosen size and weight of its reentry vehicle and the selected maximum range. From southern France to Moscow, a range of about 1,650 nautical miles is required, to Volgograd, 1,900 nautical miles, and to Sverdlovsk, 2,250 nautical miles.

For an IRBM which is planned to be deployed in 1967 or early 1968, the French must by now have selected a reentry vehicle weight based upon the size, yield, and weight of warhead they will have available at the time. Reportedly the Comissariat de l'Énergie Atomique (CEA) is procuring a centrifuge for testing at 100 g's a nosecone weighing 4,400 pounds.[29] This nosecone weight indicates that the weight of the associated nuclear warhead is of the order of 3,500 pounds. Joel Le Theule, a Gaullist deputy, speaking on budgetary matters to the Chamber of Deputies in November 1963, said, "The Government is oriented toward a surface-to-surface missile with a range of 1,350 to 1,620 nautical miles carrying an atomic warhead of 300 KT."* [30]

The French possibly will have the capability to build a 300-500-KT warhead in the 3,300-pound class by 1969. This weight is compatible with the aforementioned 4,400-pound reentry vehicle, but if such warheads will not be available until 1969, the French may not plan to employ land-based IRBM's in quantity before 1970, despite their stated intention to do so in 1967-68.

*He went on to say, "It appears that certain technicians doubt the value of this system, the French capability to build it, and wonder if the CEA will truly be able to deliver the nuclear warheads by 1968."



[redacted]

But it is highly probably that by 1970 when the first submarine missiles are required, the French will have been able to reach the following objectives which will make this missile compatible with the submarine:

(a) The warhead will have been miniaturized to be contained within a six-foot-long reentry vehicle.

(b) Propellants will have been improved in overall performance to the point where reasonable reductions in grain length can be made without diminution of missile range.

(c) Guidance packages will have become markedly lighter and smaller.*

There are no reasons why the French cannot, by 1968 or so, be testing missiles embodying all these enumerated improvements, even using dummy reentry vehicles if necessary, against the advent in the early 1970's of miniaturized weapons. [redacted]

The French appear to have a very good capability in missile guidance hardware. There are several competent firms in the general field but the preponderance of reporting indicates that the firm SAGEM (Société d'Applications Générales d'Électricité et de Mécanique) is the prime contractor for French inertial guidance systems. SAGEM is a licensee of the US firms of Northrup, Raytheon, General Precision, and Kearfott. SAGEM is producing gyros with a 0.01-degree-per-hour drift rate, which, if not under "laboratory" conditions, is very good and quite acceptable for missile guidance systems. SAGEM also produces computers and openly states in its brochures that it is designing an inertial navigation system for French submarines.

Because all French missiles will, at least at the outset, be anti-city weapons, requirements for weapon system accuracy are of relatively moderate stringency. Miniaturization of guidance systems installed in larger land-based IRBM's is required only in modest degree at present, with ample time between 1967 and 1971 to miniaturize systems fully for use in the smaller submarine missiles. The French will encounter no insurmountable difficulties with missile guidance systems within their time schedule.

For range testing of ballistic missiles, the French are presently constructing a range on the Atlantic coast south of Bordeaux near Biscarosse. By agreement with Portugal, a downrange station will be located on an island of the Azores group about 1,400 nautical miles from Bordeaux. Defense Minister Messmer publicly stated in April 1964 that missile firings will begin in 1965. Eventually, he said, the seaward Atlantic range will replace the Colomb Bechar test center in Algeria. There has been no reporting on the progress of construction of the Atlantic range but it may be assumed that work is going ahead. This range is unsuitable for satellite launchings, as firings must be in an east to west direction, that is, against the earth's rotation.

The Colomb Bechar test center, under the terms of the Evian Accord, must be vacated in the summer of 1967. Probably this is now a matter of only slight importance to the French because the range there is too short for test firing of IRBM's. The Colomb Bechar range will, however, probably be used for testing shorter range missiles of all types for some time to come unless political considerations force French withdrawal prior to 1967.

The French have another seaward range on the Île du Levant near Toulon in the Mediterranean Sea which they will probably continue to use for short-range missiles and space probes. Recent report-

ing indicates that the French are presently carrying out extensive construction work on the island.[32] The Île du Levant range is unsuitable for test firing IRBM's and the firing of satellite launchers because first stage cases would fall on foreign soil.